AAI Corporation

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FINAL REPORT,

6 DESIGN AND DEVELOP

A

SIMPLIFIED SERIAL FLECHETTE RIFLE.

~~CONTRACT NO.~~ DAAF03-72-C-0172

15

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FRONTISPIECE

XM70 RIFLE

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I. INTRODUCTION

Under Contract No. DAAF03-72-C-0172 with the U. S. Army Armaments Command, Rock Island, Illinois, AAI Corporation ~~was to conduct~~ conducted a research and development program for the purpose of simplifying the XM19 Rifle. The weapon configuration emanating from these efforts was identified as the XM70 Rifle. The program was divided into two phases - the first consisted of the research activity and the second the fabrication of two XM70 Rifles and associated ancillary equipment as per an approved Configuration Base Line (CBL). The effort was originally scheduled to be completed in a fourteen month time frame. Of this, ten months were provided for the design study and the remaining four months allotted for fabrication of the hardware. However, during the course of the program, the government modified the contract to expand the scope of work.

The goal of the program was to, through simplification, offer a system with increased reliability and effectiveneas while decreasing its weight and cost. This was to be accomplished primarily through the following design changes.

A. Simplified Trigger Group

B. Open Bolt Operation

C. One-Piece Barrel

D. Ammunition Design

The following pages of this document contain a summary of the contract goals and requirements and describe this contractor's activities and achievements. Section II presents the contract scope of work and the physical

restraints and functional characteristics stipulated as requirements or guidelines for the XM70 system. The discussions in Section III provide a cursory review of the activities performed and the results of the associated ballistic tests conducted. Section IV is a tabulation of the drawings, with appropriate revision designation, identifying the components and assemblies which comprise the Configuration Base Line (CBL) for the XM70 Rifle. An analysis of the firing pin energy is presented in Appendix A.

II. SCOPE OF WORK

A. Design Study

1. Trigger Group

a. Relocate sear for open bolt operation

b. Redesign for semi-automatic and 3-round burst operation. In addition, provide one area fire mode.

c. Incorporate necessary interchangeability features to accommodate closed bolt trigger group (i.e., XM19 mechanism) for closed bolt functioning.

2. Muzzle Device

a. Investigate effect of aerodynamically stripped sabot on performance of muzzle device.

3. Stock

a. Redesign stock to facilitate the following:

(1) Sight mount for collimator sight.

(2) Ejection port cover.

(3) Trigger group and heat sink modifications.

4. Heat Sink and Radiator

a. Consider elimination of radiator from system.

b. Modify heat sink as necessary to fulfill needs of new system requirements.

5. Ejector

a. Investigate approaches for reducing travel of spent cases.

6. Firing Pin

   a. Evaluate effect of alternate firing pin teat configurations on the all-fire energy of the primer.

7. Maintainability

   a. Develop design modifications in the areas of the buffer housing, latch and guide rod assembly to simplify and ease field stripping.

8. Collimator Sight

   a. Design and manufacture two collimator sights with the following capabilities and features:

      (1) Compatibility with GFE optical components.

      (2) Provide for internal reticle adjustment and allow for $\pm$ 2 mil adjustment after zeroing at 100 yards.

      (3) Sight shall be compatible with mounting provisions on XM70 Rifle. Mounting shall possess capability of retaining line of sight between sight and bore within 1 mil over a 1000 round firing schedule.

      (4) The mounting of the sight shall be such as to have an eye relief within the following limits . . .

         (a) Five (5) inches - minimum

         (b) Seven (7) inches - desired

         (c) Ten (10) inches - maximum (required)

      (5) The mounting of the sight shall be such that it is not necessary to remove for or inhibit field stripping.

9. 30mm Launcher

   a. Design and manufacture a single shot, 30mm launcher to conduct test firings to ascertain feasibility of system integration.

   b. Prepare necessary drawings which show modifications to the XM70 Rifle to permit retrofitting of the launcher concept.

10. Physical Restraints

a.	Empty weight with 50 round magazine	7.8 lbs max.
b.	Length	42 in. max.
c.	Trigger Pull	4-6 lbs required
d.	Compliance with TDP	CBL

11. Functional Characteristics

a.	Single shot accuracy (Machine Rest LSD)	mils max. avg.*
b.	Three round burst extreme spread	mils max. avg.*
c.	Noise (at Shooter's left ear)	160 db max.
d.	Reliability (malfunction rate)	.5% required .3% desired
e.	Cyclic Rate	Comparable to XM19 Rifle
f.	Maintainability (Field Stripping)	

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* Values to be determined pending GFE ammunition performance.

B. Delivery Requirements

1. Two (2) XM70 Rifles

2. Ten (10) 50-round Magazines

3. Technical Data Package (CBL)

4. Contract Data Requirements Per DD Form 1423.

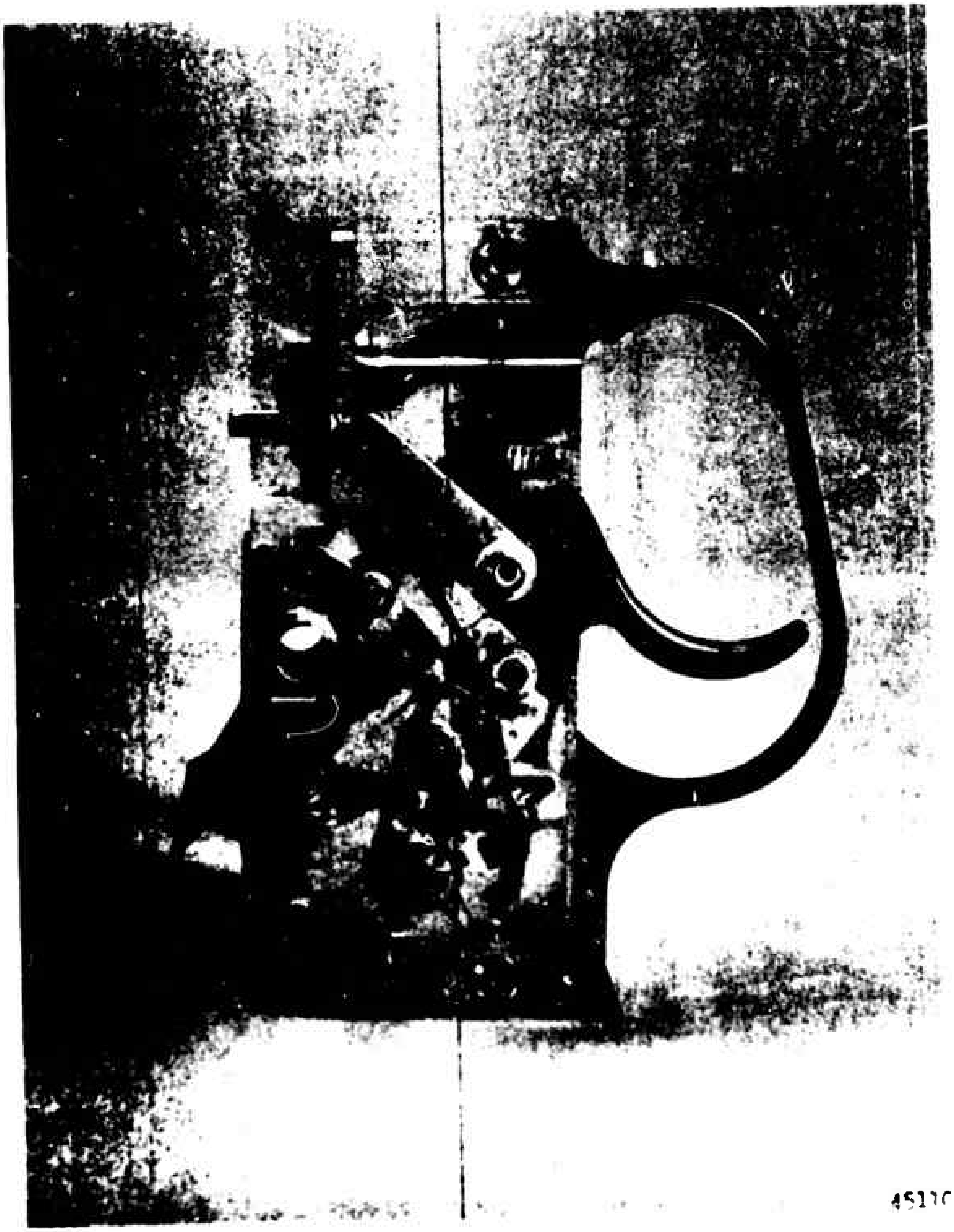
III. RESULTS OF INVESTIGATIONS

A. Trigger Group

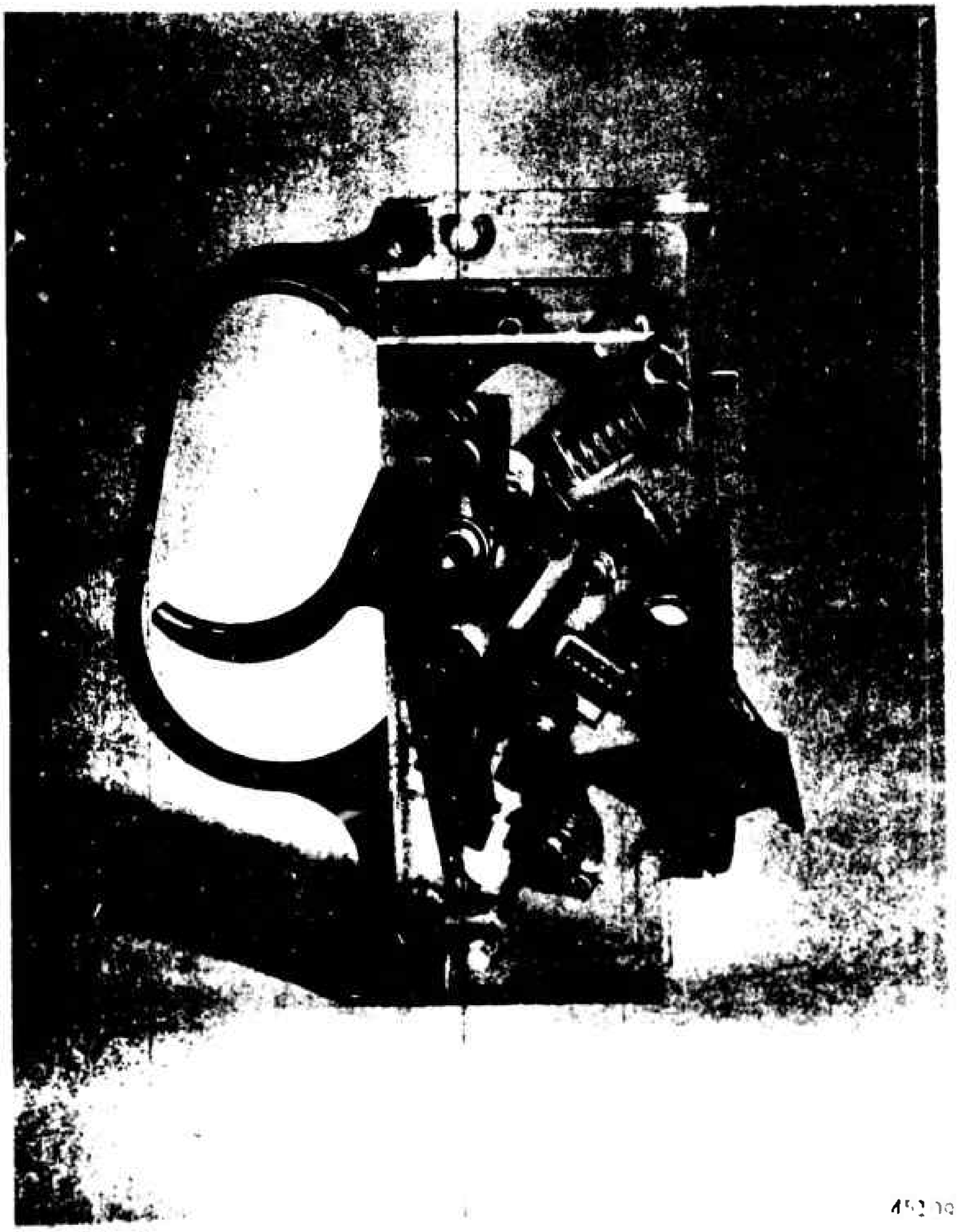
The configuration of the trigger group assembly developed for the XM70 Rifle possessed a number of the basic operating concepts contained in its XM19 counterpart. Aside from relocating the sear to accommodate open bolt operation and utilizing a pulling type motion for the counting sequence in lieu of the original pusher system, no other significant design modifications were adopted. Since the automatic mode of fire was deleted, the mechanism could be simplified and a significant reduction in weight achieved.

The photographs on pages 8 and 9 are views of the mechanism from both sides. At the conclusion of the test program a total of 5845 rounds was fired during which only one design modification was made. After firing 3845 rounds, eight (8) miscounts were encountered. The cause was traced to an overstressed counter retainer spring. After replacing the subject spring with an improved design, an additional 1000 rounds was expended and no malfunctions were experienced. This is equivalent to an overall malfunction rate of 1.4/M.

The following chart compares the salient features of the XM70 trigger group with its predecessor used in the XM19 Rifle. The greatest single factor contributing to the increased trigger pull is the higher drive spring force developed at the seared position when firing from the open bolt. From Appendix A, the spring deflectionat the seared position in the closed and open bolt systems is 8.68 and 11.86 inches respectively. With



RIGHT SIDE
TRIGGER GROUP ASSEMBLY



LEFT SIDE
TRIGGER GROUP ASSEMBLY

a spring rate of 2.2 lbs/in the corresponding forces are approximately 19 pounds in the XM19 as compared to 26 pounds in the XM70 Rifle.

Comparison of Trigger Mechanisms

Characteristic	XM70	XM19
Modes of Fire	Semi-Automatic 3-Rd Controlled Burst	Semi-Automatic Full Automatic 3-Rd Controlled Burst
Weight	.46 lb	.82 lb
No. of Parts	41	58
Trigger Pull	14 lbs	9.3 lbs*

* Based on the results of tests performed on the weapons fabricated on Contract No. DAAF03-71-C-0281.

B. Muzzle Device

The configuration of the muzzle attachment supplied on the XM70 Rifle was essentially identical to that employed with the XM19 weapon. Minor modifications were made to certain components to compensate for dimensional differences between the one-piece barrel and the previous barrel-barrel extension assembly. Also, with the advent of the collimator sight the front sight was removed from the muzzle device.

Because the test weapon was used extensively for heat tests, the barrel bore was severely eroded and considerably oversize. Because this condition can produce "slips" - abnormally low muzzle velocities, when launching the flechettes, accuracy tests were not conducted with the

aerodynamically stripped sabot cartridge. Therefore, investigations to determine if compensation related revisions would be required were not conducted. The propellant loaded in the cartridges to be used in the government evaluations of the weapon system is very similar to that contained in the XM645 cartridge. Also, the charge weight has been reduced. Consequently, it is believed that noise and flash levels will remain within acceptable levels.

C. Stock

The configuration of the stock selected for the XM70 Rifle was established from parallel investigative efforts conducted on this contract and Contract No. DAAF03-71-C-0334. Under the subject contract the guidelines for the stock design were dictated by requirements for interfacing with the collimator sight mount, incorporating an ejection port cover and modifications emanating from relocating the trigger group assembly. Also, inputs were obtained from the heat tests - elimination of the radiator, changes in the envelope of the heat sink and the addition of a deflector, which contributed to the ultimate configuration of the stock.

Concurrent with the above efforts, a number of studies were performed on Contract No. DAAF03-71-C-0334 which were instrumental in determining other features of the stock. From these paper investigations such concepts as combining the foregrip with stock and extending the magazine well to provide added support were adopted. The collimator sight with its higher line of sight necessitated raising the cheek rest area of the stock to provide a comparable eye level for aiming. Changes were made in the hand

grip area to improve structural integrity and general handling characteristics. Ribbed projections, located on each side of the stock, aid in preventing the gunner from contacting the barrel cover or inadvertently inserting his fingers into the holes.

To facilitate field stripping, the upper portion of the stock in the area of the foregrip was attached as a separate piece. This part, identified as the barrel cover, prevents the gunner from accidentally touching the barrel or heat sink and is affixed to insulators at each end. The final configuration of the stock and barrel cover, fabricated on Contract No. DAAF03-71-C-0334, is in accordance with Dwg. No. 53099-41008, Rev. B and 53099-41129 respectively. They are shown pictorally on pages 13 and 14 .

D. Heat Sink and Radiator

One of the objectives of the program was to eliminate the radiator and redefine the requirements for the heat sink. Since the weapon operates from the open bolt position, the cook-off problems associated with the XM19 Rifle were eliminated. Now, the controlling factor, aside from the human engineering aspect, was the temperature attained by the barrel.

The barrel blanks supplied by the government were made of AISI Type H11 material, heat treated to an average hardness of R_c 35. This is equivalent to a yield strength of 125,000 psi. The information on page 16 is a graphical representation of yield strength versus temperature for the 4140 material used for the XM19 barrel and two candidate materials, Inconel 718 and AISI Type H11, under consideration for use with the XM70 Rifle. To

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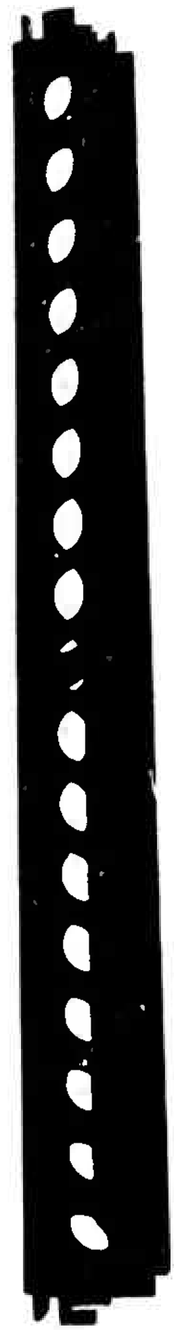

BARREL COVER

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STOCK CONFIGURATION
XM70 RIFLE

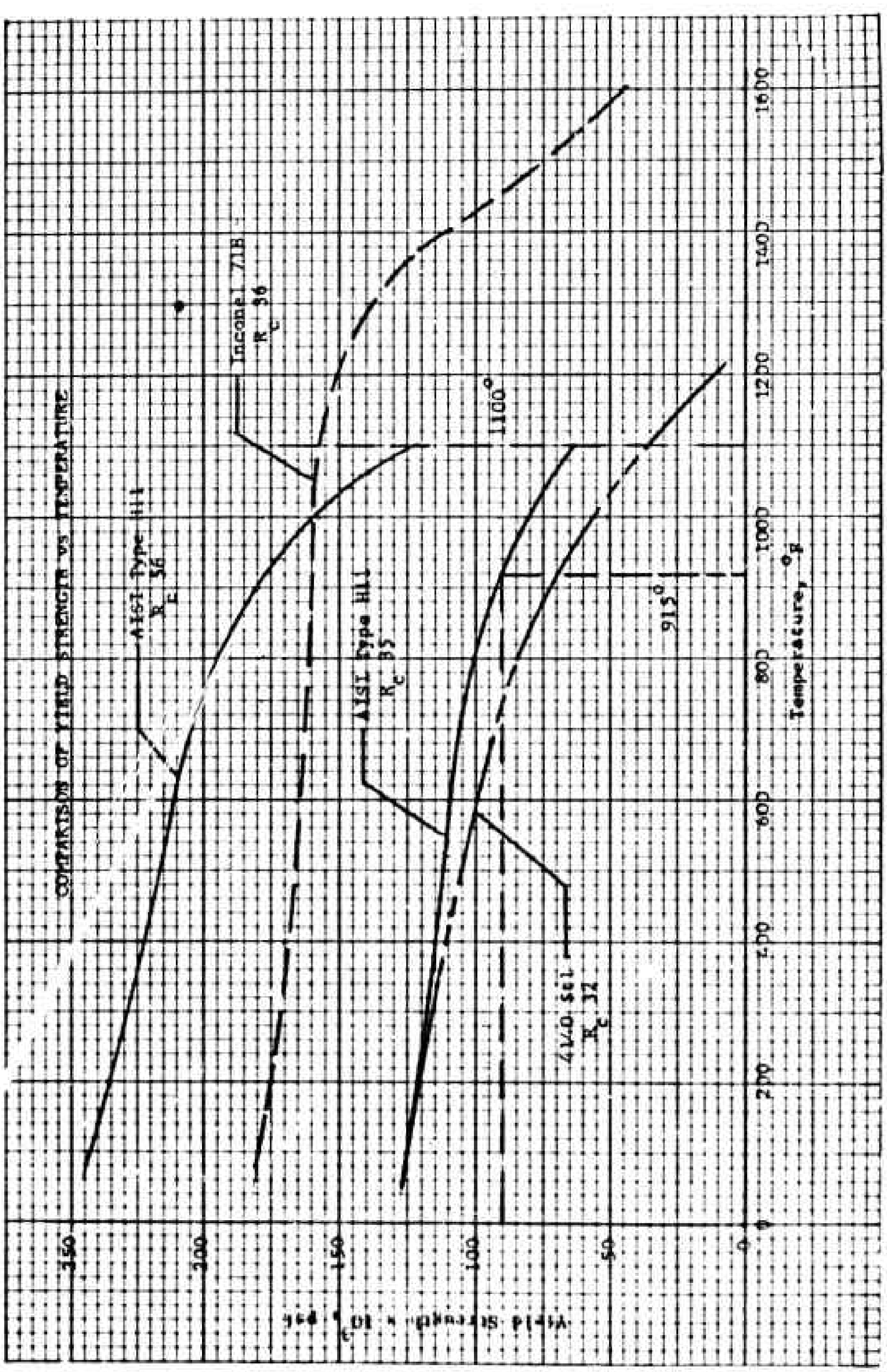
illustrate the influence of hardness, two graphs are presented for the H11 material. The data used to generate the curves for H11 steel was extracted from MIL-HDBK-5A, "Metallic Materials and Elements for Aerospace Vehicle Structures". The table below compares the values of yield strength based on exposure to the temperatures listed for up to 1/2 hour. Figure 2.5.1.2.1(b) of the aforementioned reference provides the percent reduction in the ambient temperature yield strength at these temperatures for this exposure time.

Effect of Temperature on Yield
Strength of H11 Material

Temperature °F	% Reduction In Yield Strength	Yield Strength, psi R_c 35	Yield Strength, psi R_c 56
70	0	125,000	243,000
200	97	121,000	236,000
400	92	115,000	224,000
600	87	109,000	211,000
800	80	100,000	195,000
900	73	91,000	178,000
1000	65	81,000	158,000
1100	50	63,000	122,000

For these tests, the Inconel 718, one-piece barrel supplied by the government was assembled to the test weapon. It had a nominal bore diameter of .2271 inch and a hardness of R_c 42.

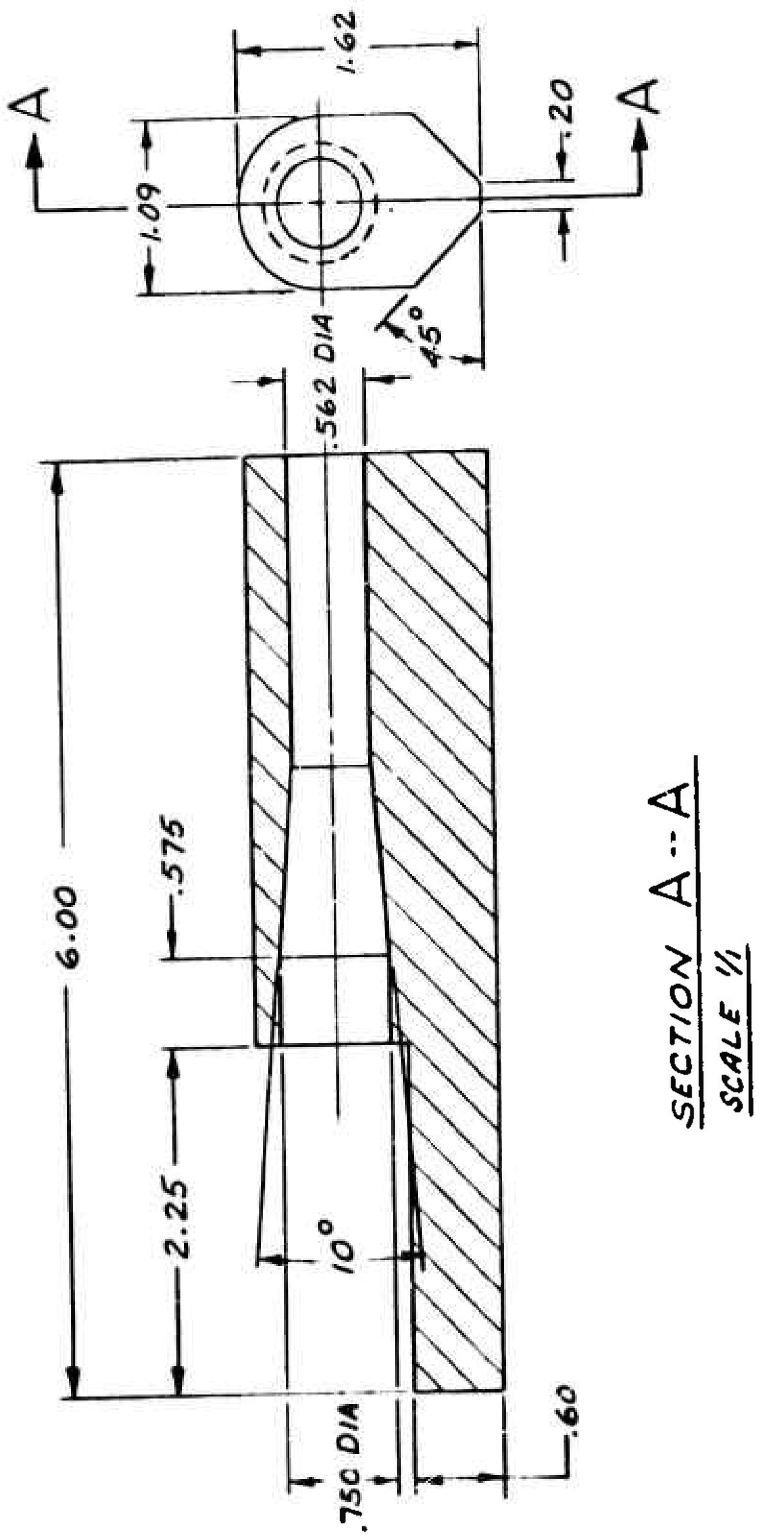
To establish a basis for any subsequent investigations the radiator and heat sink were removed. An .032 inch thick, polished aluminum shield was installed between the barrel and bottom of the foregrip. The


COMPARISON OF YIELD STRENGTH vs TEMPERATURE
Inconel 718
Rc 36
AISI Type H11
Rc 36
AISI Type H11
Rc 35
4340 Sel
Rc 32
1100°
915°
Temperature, °F
0
200
400
600
800
1000
1200
1400
1600
0
50
100
150
200
350

top of the foregrip was replaced with a metallic mesh material to increase the venting area. A pad of asbestos insulation was inserted between the sight mount and the outside diameter of the barrel to reduce the heat flow to the sight housing and optical components. The results of this test are tabulated at the top of page 19 . Note that, with this limited firing schedule, the temperature measured at the critical location - 4 inches forward of the chamber, exceeded 1200°F. Since it was impossible to predict the pressures developed at these temperature levels, and, in view of the adverse effect of temperature on yield strength, it was decided to terminate the test.

Based on these findings, a 1/2 pound heat sink was fabricated and assembled on the weapon. The sink, shown in Figure 1, is press-fitted onto the barrel in the area immediately forward of the sight mount. The schedule for the second test was predicated on firing until a temperature of 1200°F was reached at the mid-barrel location. The test was terminated when the area of the foregrip adjacent to the front radiator ignited. However, at this point, a total of 550 rounds was fired and the temperature reached 1100°F. The rate of fire for this test averaged 96 rounds per minute. A summary of the data generated from this second test is presented at the bottom of page 19 . The historical record of the temperatures monitored at the four locations during the two tests is shown graphically on page 21 and 22.

As mentioned earlier, the barrels for the two XM70 Rifles were fabricated from the H11 material. The data on page 15 indicates the yield strength of this material at 1100°F is 63,000 psi. Regardless of the



HEAT SINK CONFIGURATION
FIGURE 1

Results of Heat Tests

Test #1 - W/O Heat Sink and Radiator

A total of 200 rounds was fired in 98 seconds (120 rounds/minute)

Location	Temperature, °F
Sight Mount	200
Chamber	325
Mid-Barrel *	1185
Muzzle Device **	1455

Test #2 - W/.54 lb. Heat Sink but w/o radiator

A total of 550 rounds was fired in 344 seconds (96 rounds/minute)

Location	Temperature, °F	
	After 350 Rounds	After 550 Rounds
Sight Mount	105	130
Chamber	355	404
Mid-Barrel *	915	1100
Muzzle Device **	1560	1660

* At Point 4" Forward of Chamber

** On Barrel, Inside of Muzzle Device Chamber

exposure time, up to 1000 hours, no data was presented beyond 1100°F. Whether this implies that the test was terminated at this point or the material exhibited no measurable strength at higher temperatures is not known.

Hence, to provide some safe operating margin, it is recommended that the firing schedule for the XM70 Rifle be limited to 100 rounds per minute for a period of 3-1/2 minutes (350 rounds). Based on this the temperature developed at the critical mid-barrel location should be approximately 915°F. At this temperature, the graph on Page 16 indicates the corresponding yield strength is approximately 90,000 psi.

E. Ejector

In this area of investigation the effort primarily addressed the feasibility of utilizing a spring loaded system as a method by which the ejection pattern of the expended cases could be altered. The fixed ejector design used in the XM19 Rifle generally propels the cases to the right, rear of the gunner to a distance of approximately 30 feet. Independent investigations by this contractor and Rock Island Arsenal indicated that the response time of a spring mechanism would be too slow. By the time the spring reacted to absorb any appreciable amount of energy, the case will have been ejected with no noticeable change in the pattern characteristics.

However, a second approach evaluated considered using the ejection port cover in a dual role - to cover the breech area and as a case deflector. A projection was added to the underside of the cover which

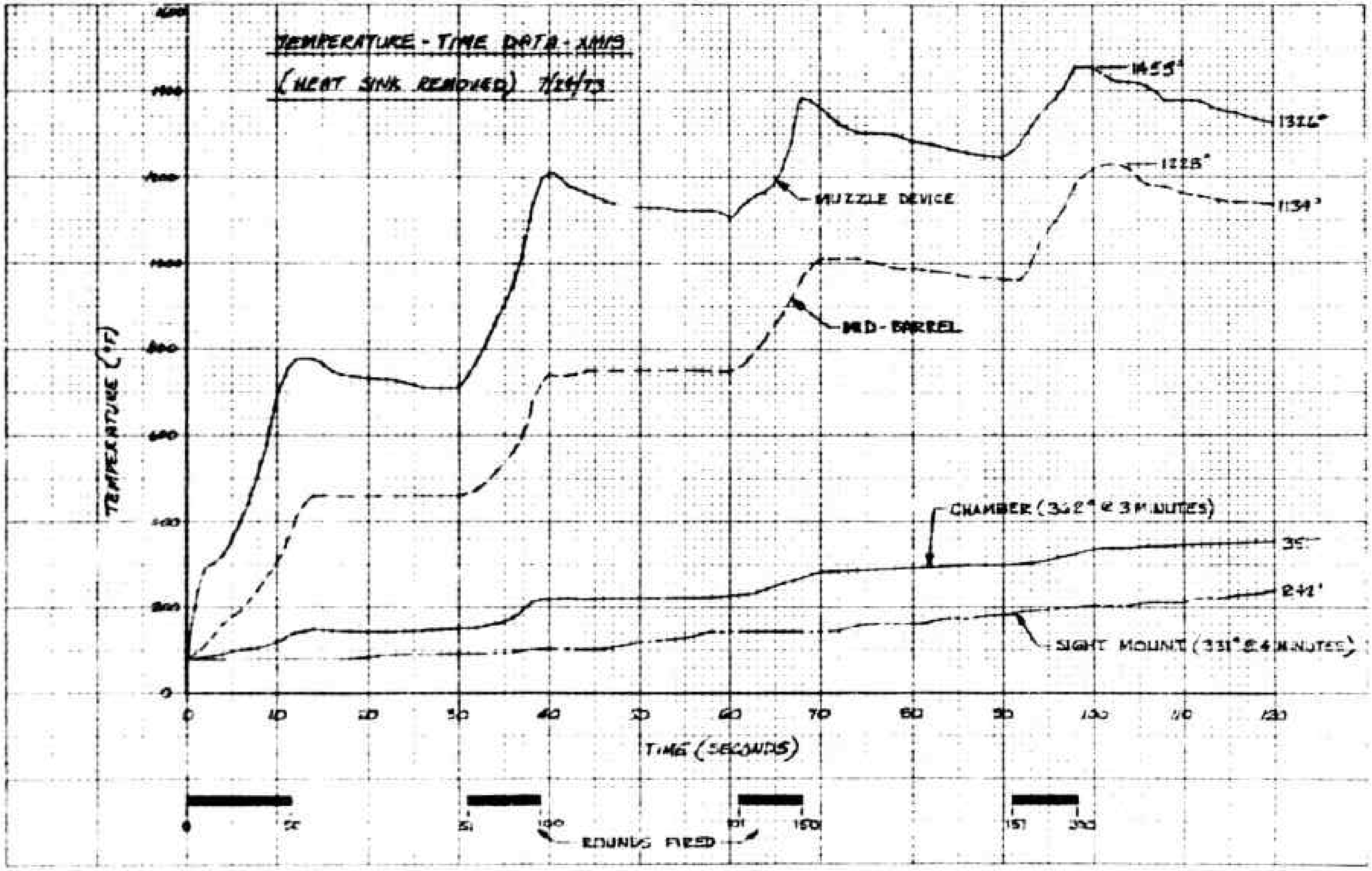

TEMPERATURE - TIME DATA - XM19
(HEAT SINK REMOVED) 7/24/73
TEMPERATURE (°F)
TIME (SECONDS)
MUZZLE DEVICE
MID-BARREL
CHAMBER
SIGHT MOUNT
ROUNDS FIRED
1455°
1326°
1228°
1134°
242°

Figure 2

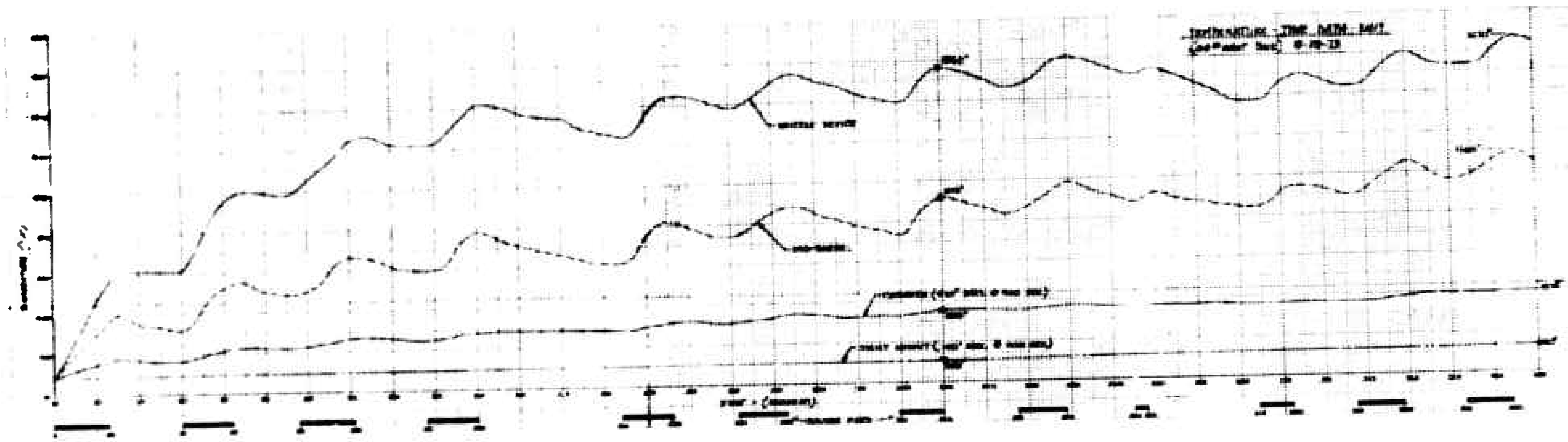


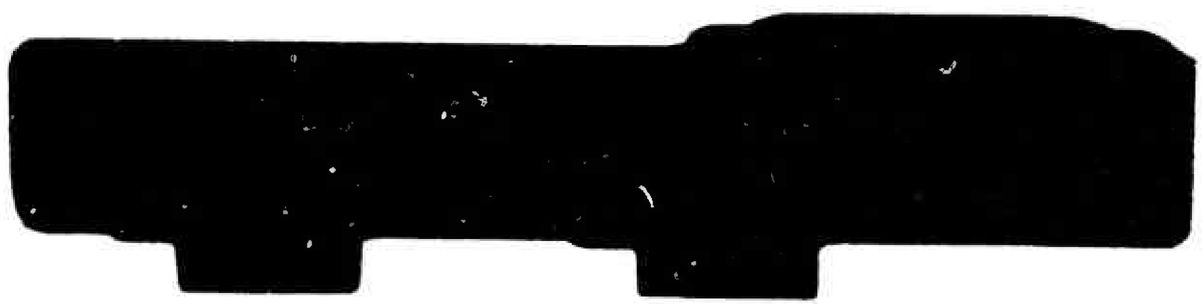
Figure 3

engaged the case as it pivoted from the face of the bolt. The subsequent contact redirected the spent case in a slightly forward and downward trajectory. It is estimated that the cases travel about 10 feet when firing from the standing position. The configuration of the ejection port cover is shown in Figure 4.

While test data as to the reliability and functional characteristics of this approach is limited, it was decided to incorporate this feature in the ejection port covers provided on the delivered weapons. Engineering tests of the XM70 Rifle scheduled by the government can be used to determine the acceptability of the design. In the event problems are encountered, it is a simple operation to remove material from the cover and permit the cases to eject unimpeded.

F. Firing Pin

In an effort to further supplement the improved ignition characteristics anticipated as a result of the increased firing energy available when firing from the open bolt, investigations were conducted to examine experimental firing pin teat configurations. The goal was to achieve a reduction in the all-fire energy requirements of the piston primer. The two candidate tip shapes tested are depicted in Figure 5. Both of the designs feature spherical radiused tip contours to prevent the occurrence of pierced primers. Also, the maximum protrusion of the teat from the face of the firing pin was increased in an attempt to obtain greater penetration. In addition to the piercing problem, a second factor that controls the teat configuration is the elongation of the web. With the present material, 1065 steel, heat treated to R_c 32-36, the maximum elongation is approximately 13 percent.



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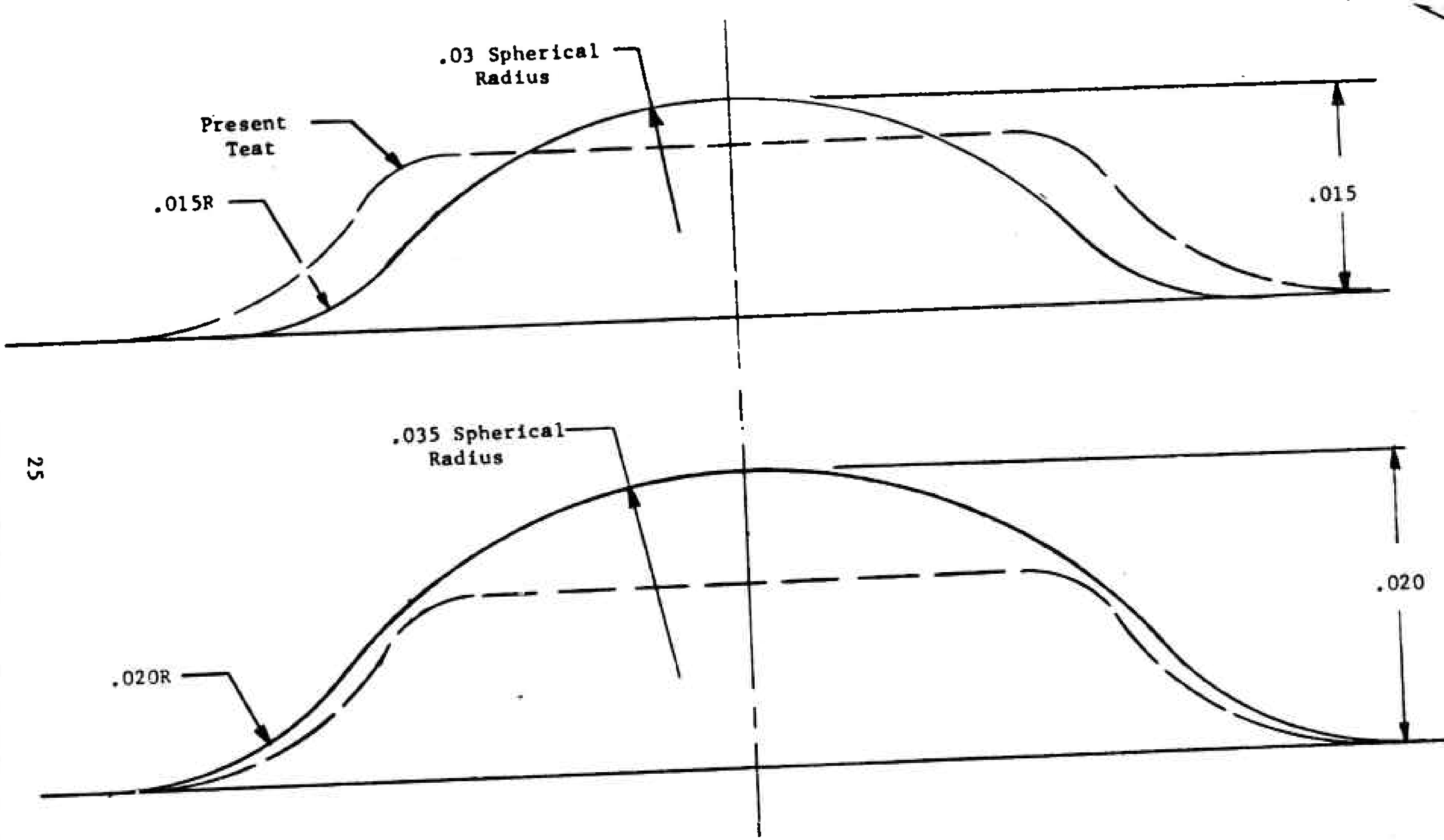
EJECTION PORT COVER

Figure 4



EXPERIMENTAL FIRING·PIN TEAT CONFIGURATIONS

FIGURE 5

The results of the sensitivity tests disclosed that the experimental shapes, based on the frequency of misfires, lessoned system sensitivity. While the depth of penetration was always greater with the experimental designs at a given input energy, until the energy exceeded 60 inch-ounces, a greater volume of composition was displaced by the standard teat configuration. This tends to lend credence to the theory that increased intergranular movement is beneficial to ignition characteristics. Based on these findings and the higher firing pin energy that will be afforded by open bolt operation, further investigation did not seem warranted.

To compare the firing pin energy of the XM70 Rifle with its predecessor, the XM19 Rifle, the analyses presented in Appendix A was performed. It utilized data generated from actual testing of the weapon during the development of the drive spring system and from information provided by evaluations at BRL. The results of this analytical review are summarized in the table below. It is immediately apparent that the XM70 system offers significant increases in firing energy which should contribute markedly to the reduction in the number of misfires experienced.

COMPARISON OF FIRING PIN ENERGY FROM THE SEAR POSITION

Weapon	New Drive Spring (in.oz.)	After 6000 Cycles (in.oz.)	Firing Pin Velocity (ft/sec)	
			New Spring	After 6000 Cycles
XM19	155 ***	94 *	12.0	9.6
XM70	485 **	163 **	21.8	12.6

* Measured - See Table 4 in ER-6571.

** After actual losses incurred as determined from T-D curves recorded at BRL

*** Obtained by subtracting the energy loss of 69 inch-ounces (Table 4 of ER-6571) from the original energy of 224 inch-ounces when the spring was new.

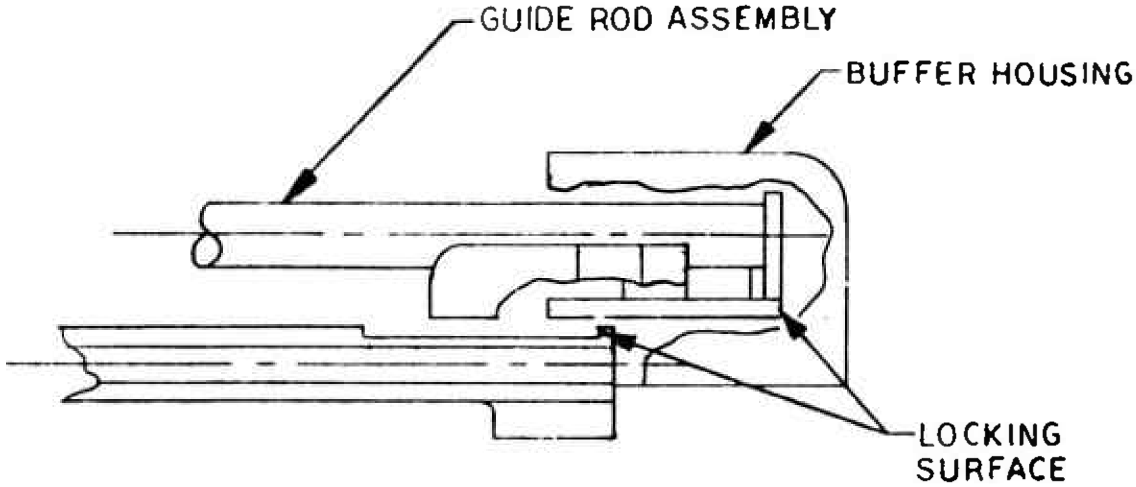
G. Maintainability

Field reports received from personnel involved in the testing of the XM19 Rifle at Ft. Ord, California during Experiment 21.9 indicated difficulties were being encountered during field stripping operations. The problems were traced to the following items:

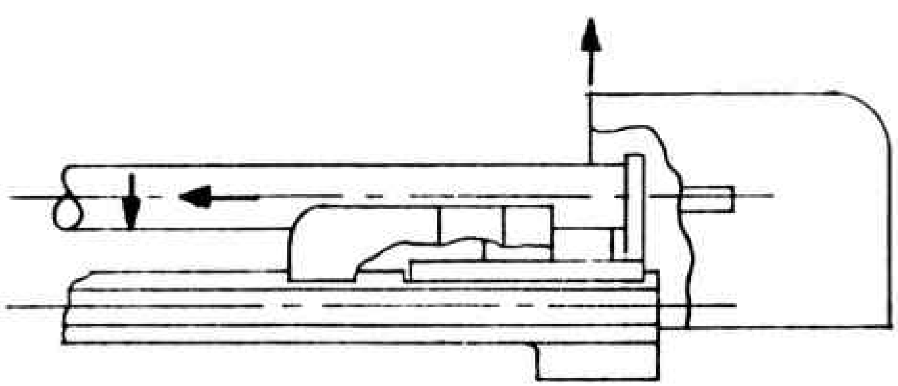
1. Difficulty in removing the buffer housing.
2. Misalignment in the tip area of the guide rod assembly.
3. Inadvertent rotation of the radiator.

In reviewing comments regarding the first of these items, it was learned that gripping the housing and manual retention of the partially compressed drive spring were the major factors contributing to this problem. To ease the removal of the buffer assembly, the projections on the sides of the housing were enlarged to facilitate gripping. Secondly, a feature was added whereby the guide rod assembly is independently supported once it is in position to permit removal of the buffer assembly.

By manually exerting a force in a forward snd downward direction while pushing the guide rod assembly forward, the buffer lock will drop into a recess provided in the top surface of the receiver. A locking notch on the resr side of this recess engages a mating edge on the rear of the buffer lock. The lock is retained in this position by the force of the compressed drive spring. Hence, it is no longer necessary for the gunner to manually overcome this force while holding the guide rod assembly and removing the buffer assembly. To reassemble, simply reverse the sequence of operations. This locking feature is depicted in Figure 6.



ASSEMBLED POSITION



FORWARD LOCKED POSITION
FOR WEAPON DISASSEMBLY

BUFFER LOCK

FIGURE 6

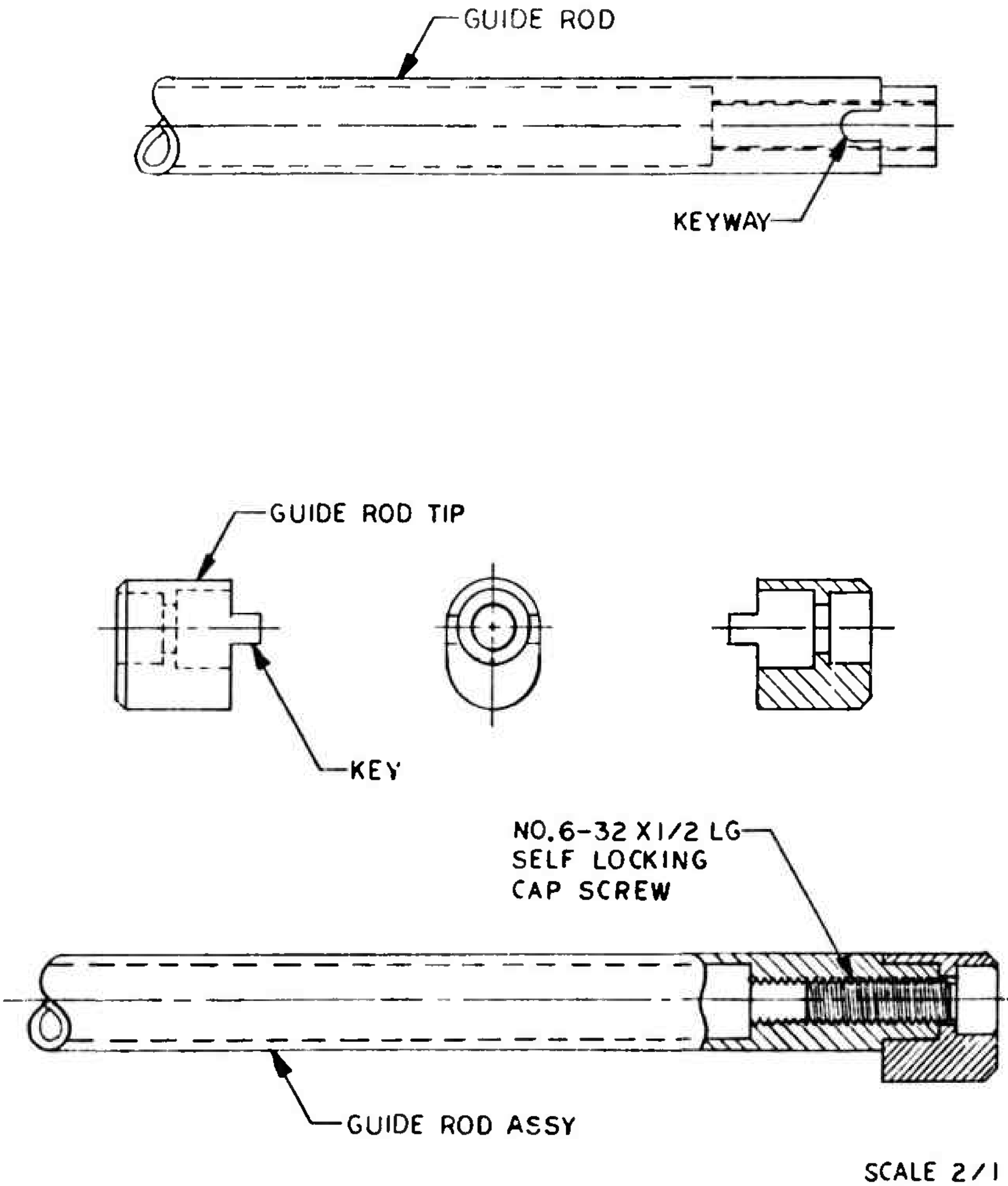
The second item, misalignment of the guide rod assembly is, in general, caused by accidental rotation of the tip. Since the assembly procedure prevents visual observation of the tip, it was necessary to insure that the concept selected would provide automatic control of the alignment. To accomplish this, a tab, or key, was added to the tip which nested in notches in the guide rod. To prevent disengagement of these interlocking projections, a self-locking cap screw was used. This design is shown in Figure 7. Since the radiator has been removed in the XM70 Rifle, problems associated with it's movement no longer exist.

The sequence of operations required to field strip the XM70 Rifle is identifical to those employed with the XM19 weapon. The photograph on page 31 shows a completely field stripped XM70 Rifle.

H. Reflex Collimator Sight

One of the major design features of the XM70 Rifle was the use of a reflex collimator sight in lieu of the conventional metal peep sight arrangement. The envelope of the sight was controlled by the optics supplied by Frankford Arsenal. The design provides for internal retical adjustment with a total movement in elevation and azimuth of 11 mils. A tridium light source is used for nightime applications.

The factors which were instrumental in establishing the position of the sight included the requirement to permit field stripping without disturbing the sight. Also, the structural integrity of the mount and overall system weight were considered. Regarding the first item, it is highly questionable that the mount could be attached to the receiver and not interfere



GUIDE ROD TIP

FIGURE 7

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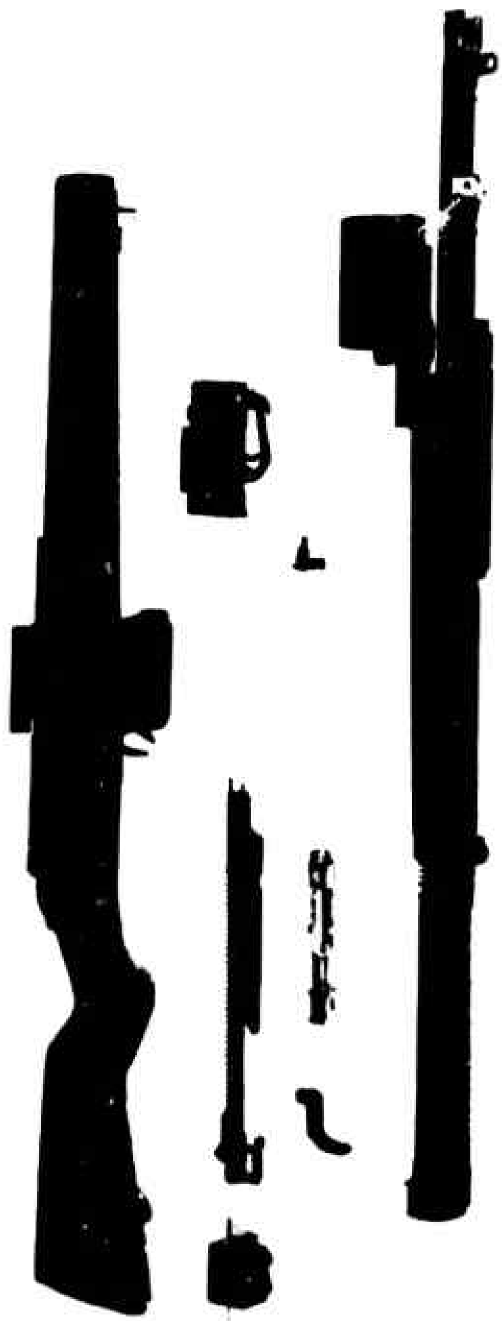
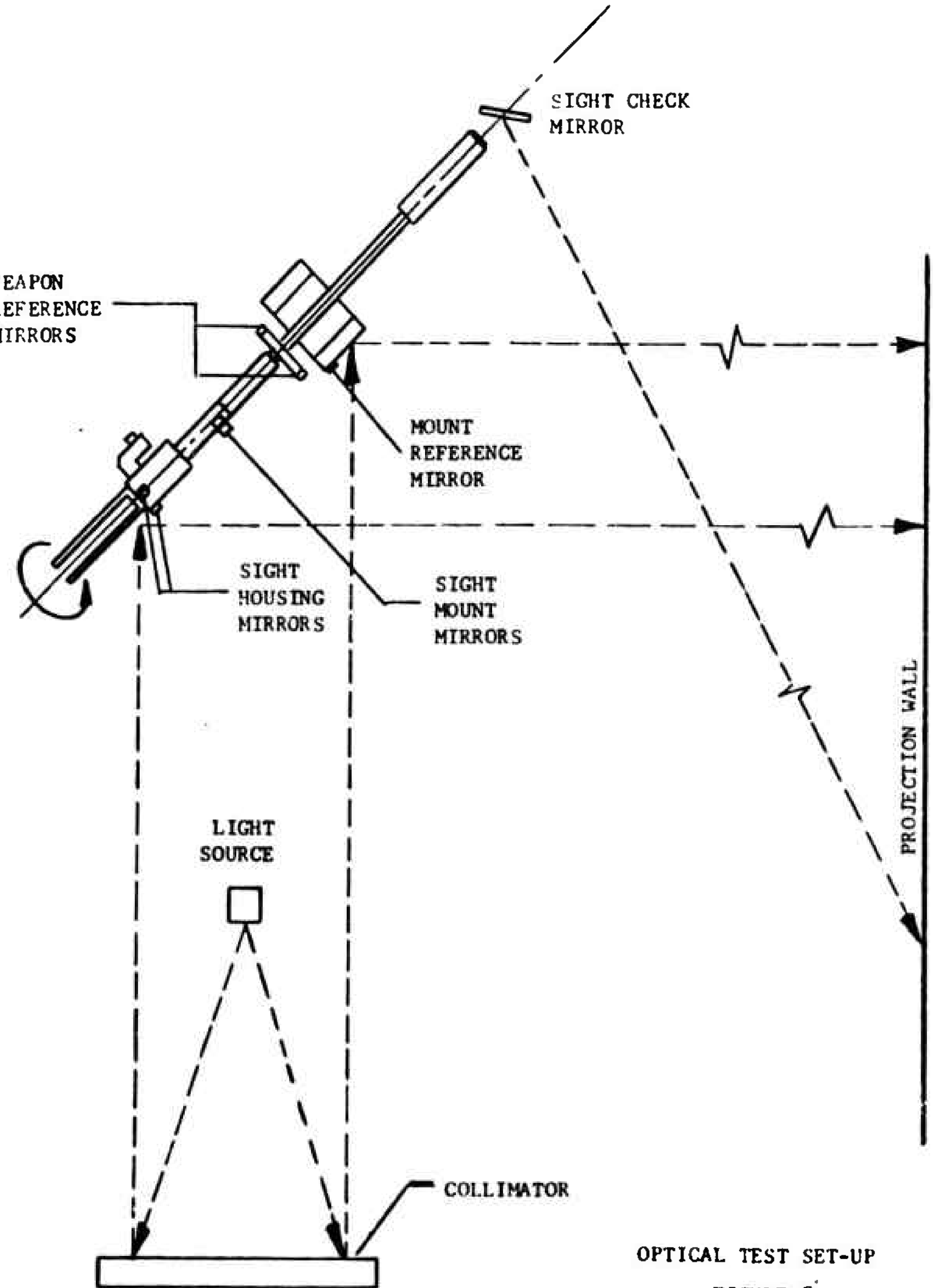


FIELD STRIPPED XM70

with field stripping without increasing the complexity of the mechanism and decreasing reliability. Furthermore, it appears impossible to attach the mount to the receiver without effecting the interface between the stock and weapon and compromising the load carrying capability of the stock.

To prevent egress of the spent cases from the breech and not impede the movement of the charging handle , mounting to the receiver is restricted to the left side. Consequently, it was decided to press-fit the mount onto the barrel immediately forward of the receiver. To minimize the length of the cantelevered mount, the sight was located to provide an eye relief of 10 inches. Also, the shorter beam minimizes the weight of the mount. As presently configured, the sight and mount weigh .71 and .16 pound respectively.

One of the functional specifications of the sight/mount relationship required that the line of sight between the sight and bore be retained within 1 mil during a 1000 round firing schedule. To record any relative movement, the optical arrangement sketched in Figure 8 was developed. Mirrors were attached to the sighting fixture and weapon to provide reference points and insure the weapon is positioned uniformly in the set-up. Additional mirrors were bonded to the top and side of the sight mount and housing to monitor movement in these components. The zero position of the reticle was marked on the witness panel. By recording the changes in the location of the light reflected from these mirrors, it was possible to ascertain whether the movement, if any, was produced by optical or mechanical factors.



OPTICAL TEST SET-UP

FIGURE 8

The test program consisted of conducting the firing schedule tabulated in the following chart. Including the zero position, measurements were made of reticle movement seven times during the exercise. It should be noted that for the first 200 rounds fired the reticle was fixed. The maximum radial displacement of the reticle from its zero position was .213 mil. This is considerably within the 1 mil requirement. An external view of the reflex collimator sight is shown in the photograph on page 35.

Results of Tests to Measure Relative Movement
Between Boresight and Line of Sight

No. of Rounds Fired	Radial Displacement, R (mils)
100	R_1 = .120
200	R_2 = .213
300	R_3 = .160
500	R_4 = .160
700	R_5 = .160
1000	R_6 = .160

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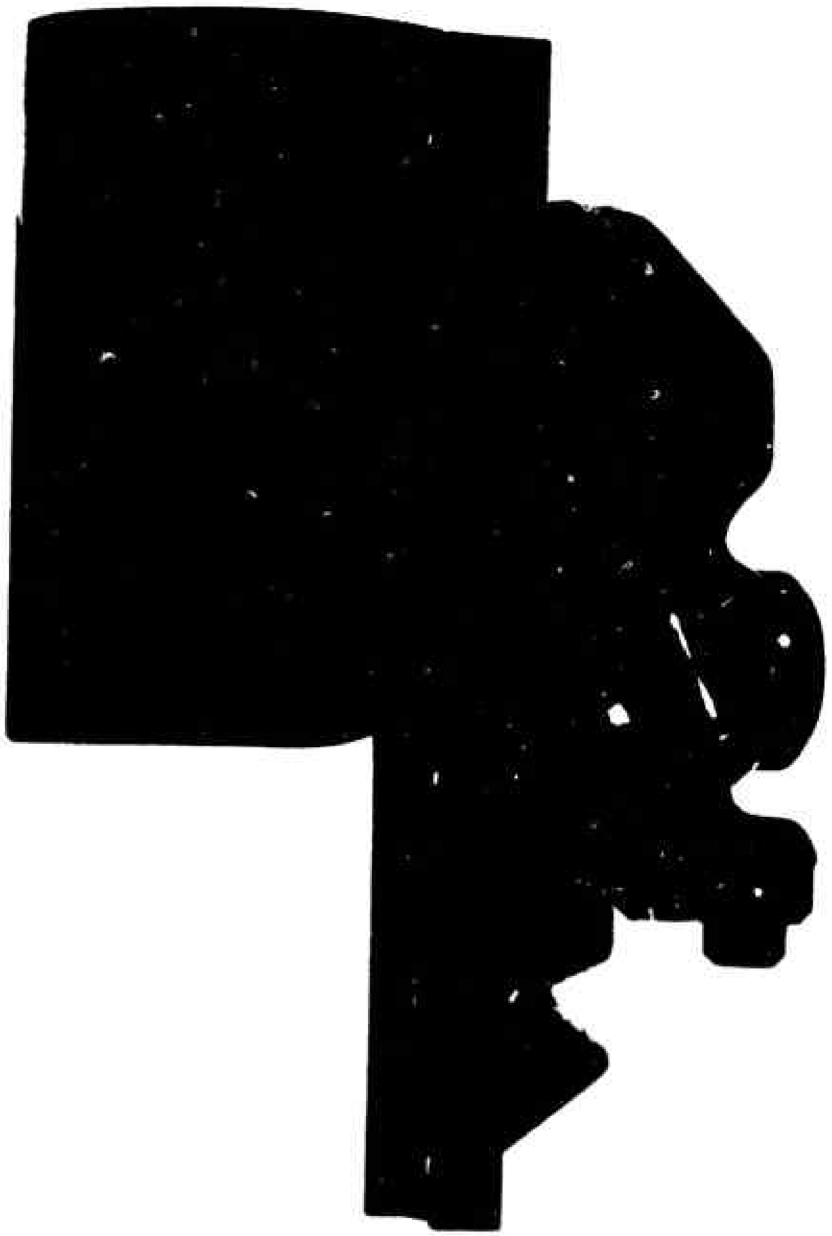


REFLEX COLLIMATOR SIGHT

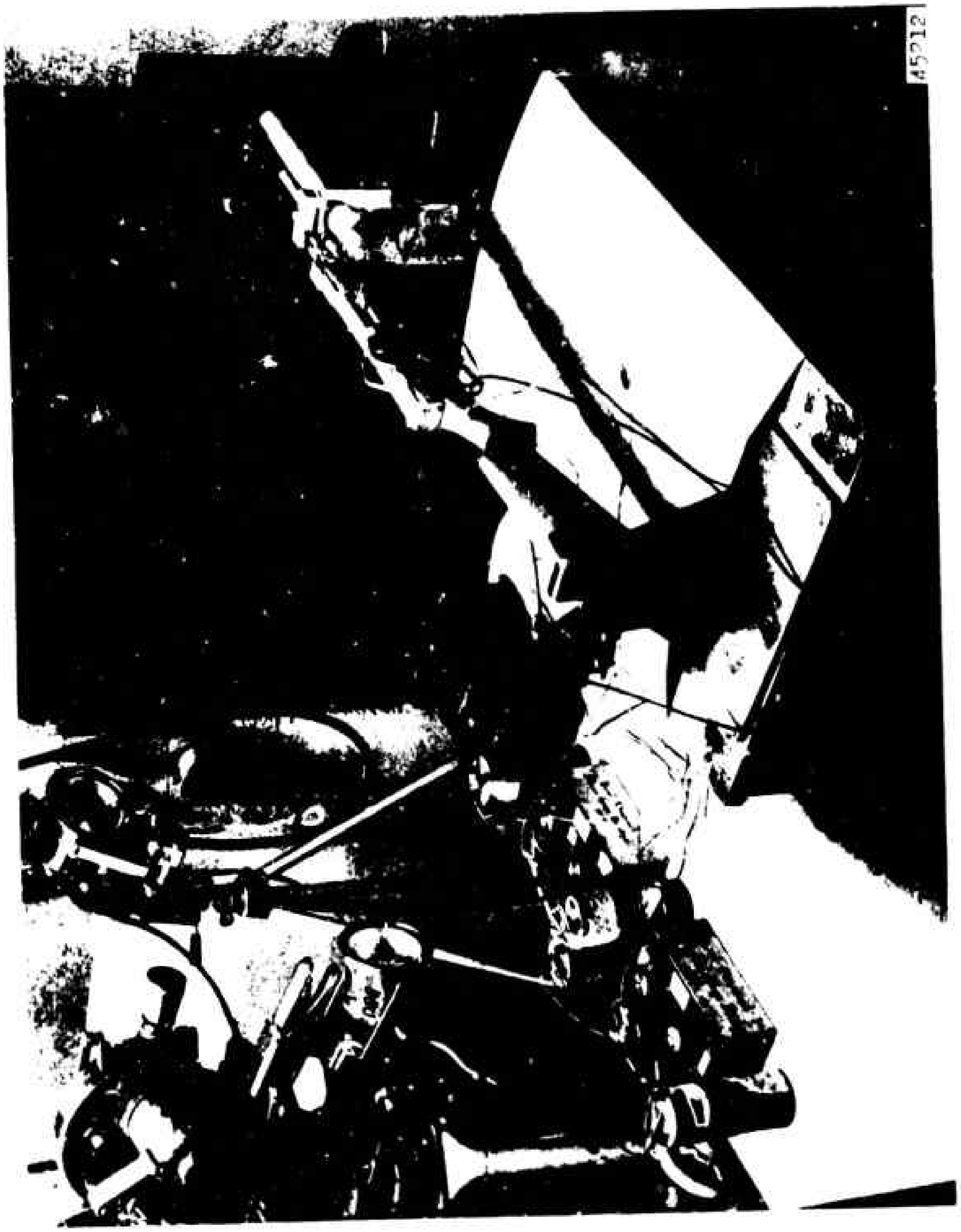
I. 30MM Launcher

One of the requirements of the scope of work was to design and fabricate a single shot, 30mm launcher mechanism that could be attached to an XM19 Rifle with a modified stock. The purpose of this effort was to conduct a series of firings whereby the stress developed in the stock could be monitored and a determination made relative to the strength capabilities of the stock. The firing fixture was designed to insure that, when assembled to the rifle, the recoil forces would be imparted directly to the stock.

The overall test set-up is depicted in the photograph on the following page. A total of five cartridges from Lot MHR1-1, 07-73 was fired for these evaluations. In an effort to record the extremes in loads imparted to the stock, firings were made with both fully loaded and empty magazines. The following chart contains data relative to the cartridge and firing mechanism.

Cartridge Weight	.43 lbs
Projectile Weight	.38 lbs
30mm Barrel Weight	.84 lbs
30mm Magazine Weight . . .	.21 lbs
30mm Breech Weight	.71 lbs
Total Weight of Launcher .	1 76 lbs

Instrumentation consisted of recording muzzle velocity, taking highspeed movies and measuring the stress levels at four selected locations. Prior to attaching the strain gages, a coating was applied to the entire stock which, after firing, identified the pattern and location of the stresses developed. This aided in positioning the strain gages. The stresses were monitored at the following locations:



30MM LAUNCHER TEST SET-UP

1. Top, right side of hand grip
2. Left side of stock, over the trigger and near the bottom of the stock
3. Right side of stock just below sear pin boss
4. Left side of stock just aft of launcher/stock interface

With the mechanism loaded with three cartridges, the maximum stress attained was approximately 11,000 psi. By comparison, with an empty magazine the stress level reached 29,000 psi. The highest stress was at Location No. 4. Since the barrel was not rifled, friction losses were virtually eliminated. This accounted for the higher than normal muzzle velocity which averaged 303 ft/sec. The data from the test is tabulated in the chart below.

Results of Launcher Tests

Round No.	Muzzle Velocity (fps)	Maximum Strain - $\mu \varepsilon$ Channel No. 1	Channel No. 2	Channel No. 3	Channel No. 4	Remarks
1	NR	NR	NR	NR	NR	Used weighted dummy magazine
2	292	500	600	800	$\approx$7000	Used weighted dummy magazine
3	304	NR	NR	1000	>14000	Used empty dummy magazine
4	315	700	NR	1000	18000	Used empty dummy magazine
5	302	600	>3000	1000	18000	Used empty dummy magazine
Avg.	303	-	-	-	-	NR - No Record

A comparison of the launcher weights of the AAI test device and the Rock Island Arsenal semi-automatic mechanism disclosed the following correlation. The weight of the fully loaded AAI mechanism and an empty RIA multi-shot launcher are essentially the same. Based on this it is estimated that the maximum stress produced in the stock when firing the RIA semi-automatic configuration with an empty magazine will be comparable in magnitude to that obtained when firing the fully loaded AAI test mechanism - approximately 11,000 psi. At this stress level the stock design provides a substantial margin of safety.

J. Physical Characteristics

1. Weight -

Rifle, empty - - - - - - - - - - - - - - - 7.5 lbs

Rifle, w/loaded 50 round magazine - - - 8.6 lbs

2. Length -

Overall length of rifle - - - - - - - - - 42.5 in.

3. Trigger Pull -

Force required to pull trigger - - - - - 14 lbs

IV. CONFIGURATION BASE LINE

The Configuration Base Line (CBL) for the XM7C Rifle is in accordance with the Technical Data Package as described by the list of drawings tabulated on the following pages.

LIST OF DRAWINGS

CONFIGURATION BASE LINE FOR XM70 RIFLE

Dated: 30 March 1974

Drawing No.	Revision	Drawing Title
53099-41001	None	Weapon Assembly, XM70
-41002	A	Stock Assembly
-41003	None	Barrel/Receiver Assembly
-41004	None	Bolt/Extractor Assembly
-41005	None	Buffer Housing Assembly
-41006	None	Drive Spring Assembly
-41007	A	Trigger Group Assembly
-41008	C	Stock, Gun, Shoulder
-41009	None	Maintenance Kit Assembly
-41010	None	Selector Lever Assembly
-41011	None	50 Round Box Magazine Assembly
-41012	None	Sling Assembly
-41013	None	Firing Pin
-41014	A	Handle, Charging
-41015	None	Cleaning Rod, Maintenance Kit
-41017	None	Oil Container, Maintenance Kit
-41018	None	Cap, Maintenance Kit
-41019	None	Oil Dabber, Maintenance Kit
-41020	None	Patch Container, Maitenance Kit
-41021	None	Tool Holder, Maintenance Kit
-41022	None	Patch Tip, Maintenance Kit
-41023	None	Brush, Maintenance Kit
-41024	A	Extractor
-41025	None	Extractor Plunger
-41026	None	Spring, Compression,Extractor
53099-41027	A	Bolt Sleeve

LIST OF DRAWINGS (continued)

CONFIGURATION BASE LINE FOR XM70 RIFLE

Dated: 30 March 1974

Drawing No.	Revision	Drawing Title
53099-41028	None	Buffer Housing
-41029	None	Buffer Spring
-41030	None	Drive Spring, Single Strand
-41031	None	Drive Spring, Tri-Strand
-41032	None	Slide, Charging
-41033	None	Guide Rod Weldment
-41034	A	Buffer Lock
-41035	None	Guide Rod
-41036	None	Guide Rod Tip
-41037	None	Follower, 50 Round Magazine
-41038	None	Rivet, Box Magazine
-41039	None	Bottom Cover, Box Magazine
-41040	None	Spring, Box Magazine
-41041	None	50 Round Box Magazine Weldment
-41042	B	P.F. Actuator Lock
-41043	B	Counter Puller
-41044	A	Counter Retainer
-41045	B	P. F. Actuator Arm
-41046	B	Sear
-41047	None	Shaft, Counter
-41048	C	Trigger
-41049	A	30mm Actuator Lock
-41050	A	Operator
-41051	B	Selector
-41052	B	Housing-Trigger, Left Side
53099-41053	B	Housing-Trigger, Right Side

LIST OF DRAWINGS (continued)

CONFIGURATION BASE LINE FOR XM70 RIFLE

Dated: 30 March 1974

Drawing No.	Revision	Drawing Title
53099-41054	A	Pins
-41055	None	Bushing
-41056	None	Safety Spring, Helical Torsion
-41057	A	Counter Spring, Helical Torsion
-41058	A	Trigger Guard
-41059	None	30mm Actuator Arm
-41060	A	Pin, Counter Puller
-41061	None	Seal, Side
-41062	None	Boot, Trigger Housing
-41063	A	Counter
-41064	C	Safety
-41065	None	Pin, Actuator Lock
-41066	A	Sight Mount
-41067	B	Retainer
-41068	B	Spacer
-41069	B	Cell
-41070	A	Retainer, Rear Window
-41071	A	Retainer, Reticle Assembly
-41072	A	Frame, Reticle
-41073	A	Sleeve
-41074	None	Spring, Compression
-41075	F	Shield
-41076	None	Screw, Pivot
-41077	None	Screw, Self-Sealing
-41078	None	Washer, Spring
53099-41079	A	Detent, Reticle Adjustment

LIST OF DRAWINGS (continued)

CONFIGURATION BASE LINE FOR XM70 RIFLE

Date: 30 March 1974

Drawing No.	Revision	Drawing Title
53099-41080	A	Cover
-41081	None	Pad
-41082	B	Mirror Mounting Plate
-41083	A	Retainer
-41084	A	Knob, Reticle Adjustment
-41085	A	Cover, Reticle Adjustment
-41086	A	Mirror, Bonded
-41087	None	Cell Assembly
-41088	B	Housing, Main
-41089	None	Reticle Assembly
-41090	None	Cover Assembly
-41091	A	Sight, Reflex, Assembly
-41092	None	Sight, Reflex, Installation
-41093	Sht 1-B Sht 2-A	Receiver
-41094	None	Barrel
-41095	None	Ejector, Fixed
-41096	B	Insulator, Front
-41097	None	Swivel Assembly
-41098	None	Pin, Muzzle Device
-41099	A	Front Radiator
-41100	None	Insert, Muzzle Device
-41101	None	Muzzle Device Assembly
-41102	None	Plates; Vane, Rear
-41103	A	Plug, Muzzle Device
53099-41104	None	Bottom Plate, Muzzle Device

LIST OF DRAWINGS (continued)

CONFIGURATION BASE LINE FOR XM70 RIFLE

Dated: 30 March 1974

Drawing No.	Revision	Drawing Title
53099-41105	None	Cone, Muzzle Device
-41106	None	Chamber, Muzzle Device
-41107	A	Front Plate, Muzzle Device
-41108	A	Pad, Butt Plate
-41109	A	Plug, Stock
-41110	A	Butt Plate
-41111	None	Bushing, Butt Plate
-41112	None	Spring Stop, Butt Plate
-41113	None	Spring, Compression, Butt Plate
-41114	None	Pin, Sear
-41115	None	Plunger, Sear Pin
-41116	None	Selector Lever
-41117	None	Detent, Selector
-41118	None	Plunger, Selector
-41119	None	Tie Strap, Muzzle Device
-41120	B	Latch, Magazine
-41121	None	Sear Stop
-41122	None	Spring, Compression, Counter Puller
-41123	None	Spring, Compression, Operator
-41124	A	Spring, Compression, Counter Retainer
-41125	None	Spring, Compression, P. F. Actuator Lock
-41126	None	Pin, Guide - Counter Retainer Spring
-41127	None	Counter Retainer Assembly
-41128	B	Case Deflector and Dust Cover
-41129	None	Barrel Cover
53099-41130	B	Heat Sink

LIST OF DRAWINGS (continued)

CONFIGURATION BASE LINE FOR XM70 RIFLE

Dated: 30 March 1974

Drawing No.	Revision	Drawing Title
53099-41131	None	Insulator, Rear
-41132	A	Spring, Case Deflector and Dust Cover
-41133	None	Pin, Case Deflector and Dust Cover
-41134	None	Insulator, Sight Mount
-41135	None	Heat Shield
53099-41136	None	Nameplate, XM70

APPENDIX A

ANALYSIS OF FIRING
PIN ENERGY

• For the present XM19 weapon -

Free length of drive spring = 18.21" } From pg. C-10
Installed length (at battery) = 10.30" } of ER-6571

Spring deflection @ battery, x_{bat} = 7.91"

*Spring deflection @ buffer, x_{buf} = 7.91 + 4.06 = 11.97"

From data sheet on page C-10 of ER-6571 the spring rate, K, is 2.2 #/in.

Hence, the useful spring energy is

$$E_s = \frac{1}{2} K [(x_{buf})^2 - (x_{bat})^2]$$

$$= \frac{2.2}{2} [(11.97)^2 - (7.91)^2]$$

$$= 1.1(143 - 63) = 88 \text{ in-lbs}$$

The energy required to compress the buffer spring .08" is

$$E_{buf} = \frac{1}{2} K (x)^2 \qquad \text{Where: } K = 2000 \text{ lbs/in}$$

$$= \frac{2000}{2} (.08)^2 = 1000 \times .0064 = 6.4 \text{ in-lbs}$$

Hence, the total available energy to the firing pin is

$$E_{fp} = E_s + E_{buf} = 88.0 + 6.4 = 94.4 \text{ in-lbs}$$

From T-D curves obtained at BRL during the drive spring study (see pg. C-12 of ER-6571) the velocity at battery was

$$V_{bat} = 24.6 \text{ ft/sec}$$

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* This consists of 3.98" firing pin travel plus an estimated .08" compression of the buffer spring.

Therefore, the kinetic energy was

$$KE = \frac{1}{2} MV^2 = \frac{1}{2} \times \frac{.34}{32.2} (24.6)^2 \times 12$$

$$= 38.6 \text{ in-lbs}$$

Hence, the losses in firing pin energy in traveling from the compressed buffer position to battery are

$$E_L = E_{fp} - KE = 94.4 - 38.6 = 55.8 \text{ in-lbs}$$

This represents 59% of the original energy.

With the open bolt system, the firing pin will travel 3.95 inches from its seared position to battery. Since it will be seared in the SA mode and prior to firing the first round of a 3-round burst, any input energy from the buffer spring must be omitted. Therefore, the available energy in the firing pin will be that provided by the spring alone or

$$E_{fp} = \frac{1}{2} K \left[(x_{sear})^2 - (x_{bat})^2 \right]$$

$$= \frac{1}{2} \times 2.2 \left[(11.86)^2 - (7.91)^2 \right]$$

$$= 1.1 \ (141 - 63) = 86 \text{ in-lbs}$$

Assuming equivalent losses, the available energy at battery will be

$$E_{bat} = E_{fp} - E_L = 86 - 55.8 = 30.2 \text{ in-lbs}$$

or approximately 485 inch ounces.

The firing pin velocity would be

$$V_{fp}^{\ 2} = \frac{32.2 \times 30.2 \times 2}{.34 \times 12} = 475$$

$$V_{fp} = 21.8 \text{ ft/sec}$$

It should be noted that these energy levels are based on a new drive spring. The energy to the firing pin in the XM70 rifle after 6000 cycles was determined as follows. From Table 4 on Page 14 of ER-6571, the spring energy from sear to battery for the XM19 rifle was 163 inch ounces. As a new spring, the energy was

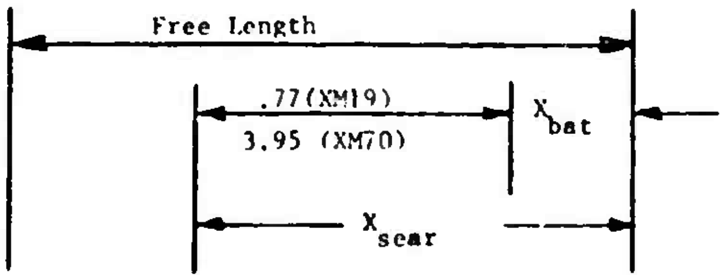
$$E = \frac{1}{2} k \left[(x_{sear})^2 - (x_{bat})^2 \right]$$

$$= \frac{1}{2} \times 2.2 \left[(8.68)^2 - (7.91)^2 \right]$$

$$E = 1.1(75.5 - 63)\ 16 = 1.1 \times 12.5 \times 16$$

$$= 220 \text{ inch ounces}$$

Based on the reduced value of 163 inch-ounces, the spring deflections at battery and sear in the XM19 rifle were determined. Because of the permanent set in the spring, the actual spring deflections at these positions will be less.



For the XM19 Rifle,

$$E_{S-B} = \frac{1}{2} K[(X_{sear})^2 - (X_{bat})^2]; X_{sear} = X_{bat} + .77$$

$$163 = \frac{1}{2} \times 2.2[(X_{bat} + .77)^2 - (X_{bat})^2] \times 16$$

$$163 = 1.1[(X_{bat})^2 + 1.54 X_{bat} + .59 - (X_{bat})^2] \times 16$$

$$163 = 1.1(1.54 X_{bat} + .59)16$$

$$163 = 27.1 X_{bat} + 10.4$$

$$X_{bat} = \frac{152.6}{27.1} = 5.63''$$

Therefore,

$X_{sear} = 6.40''$ for the XM19

$X_{sear} = 5.63 + 3.95 = 9.58''$ for the XM70

Comparing 5.63" to the deflection of 7.91" at battery when the spring was new, indicates a set of 2.28" and a free length of 15.93".

For the XM70, the energy to the firing pin from the seared (open bolt) position after 6000 cycles will be

$$E_{S-B} = \frac{1}{2} K [(X_{sear})^2 - (X_{bat})^2]$$

$$= \frac{1}{2} \times 22 [(9.58)^2 - (5.63)^2]$$

$$= 1.1(92 - 32) = 66 \text{ in-lbs}$$

With a loss of 55.8 in-lbs, the energy at battery in the XM70 is

$$E_B = 66.0 - 55.8 = 10.2 \text{ in-lbs}$$

or approximately 163 inch-ounces.

Therefore, it is anticipated that, in the XM70 Rifle, the energy available at battery will vary from 485 inch-ounces, when the spring is new, down to 163 inch-ounces after 6000 cycles.